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BRITE/EURAM: Third Technological Days 1990

J.F. Blackburn

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The Third Technological Days for the Basic Research in Industrial Technologies in Europe/European Research in Advanced Materials (BRITE/EURAM) Program was held in Brussels, Belgium, May 21-22, 1990. The BRITE portion of the program concentrates on integrating several enabling technologies and disciplines, such as mechanics, optics, acoustics, and fluid dynamics in design and manufacturing. The EURAM deals with the development of new industrial materials and improvement of the materials life cycle of production, transformation, and recovery.

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Introduction

The Third Technological Days for the Basic Research in Industrial Technologies in Europe/European Research in Advanced Materials (BRITE/EURAM) Program was held in Brussels, Belgium, May 21-22, 1990. The conference was attended by about 1,500 delegates from all the 12 members of the European Commission (Commission). This compares with about 1,200 for the second technological days and about 1,000 for the first.

The BRITE portion of the program concentrates on integrating several enabling technologies and disciplines, such as mechanics, optics, acoustics, and fluid dynamics in design and manufacturing. Work in the manufacturing fields deals with both flexible small-scale manufacturing technologies and mass production technologies, including assembly, cutting and stamping technologies, and flexible workshops. Research in chemical engineering covers separation technologies, molecular engineering, catalysis, and surface science.

The EURAM deals with the development of new industrial materials and improvement of the materials life cycle of production, transformation, and recovery. In the raw materials sector, research covers improvement of prospecting methods, study of the impact of the mining industry on the environment, and the recycling of wastes and residues from industries such as electronics, motor vehicles, aerospace, and petrochemicals. In the advanced materials sector, the emphasis is on materials with high-performance structures including metals, ceramics, polymers, and composites. Also, it will include certain special materials such as conducting polymers, superconductors, and high-performance magnetic materials.

A summary of the speeches, given in the plenary sessions and in the technical sessions that I attended, are given in the following sections of this report. Technical reports were given in three parallel sessions.

Opening Plenary Session

Five speeches were given in the opening plenary by Commission executives, the European Parliament, and industry.

Opening Address, Mr. F.M. Pandolfi, Vice President of the Commission

Two points must be made about the research that is supported under BRITE/EURAM and the clients for that research. First, it should be said that the particular specialization of Europe is in the application of advanced technologies to traditional sectors, such as textiles and mechanics. Thirty years ago we made a big mistake in our predictions. At that time, all the experts were saying that the future in the textile industry lay with the newly industrializing countries and that Europe should look to the high electronics technology world for its future. Of course, what has happened has been exactly the contrary. We now import Dynamic Random Access Memory from, for example, Korea. However, we have a thriving textile sector that adds considerable value to the new cloth it receives outside Europe. Now it is essential that Europe not lose this competitive edge in the more traditional industries. This is one of the chief aims of BRITE/EURAM--to transfer the latest technology to what is often regarded as Cinderella industries.

The second point is the special role that small- and medium-sized enterprises (SMEs) play in Europe. We have a very large number of SMEs formed by talented entrepreneurs. They are constantly seizing the initiatives offered by new technologies and developing them into products and processes. This particular feature of European SMEs has long been recognized, and the BRITE/EURAM program has made a particular effort to encourage SME participation in research at the most advanced technical level. Twenty percent of partners in BRITE/EURAM projects are SMEs.

Looking to the near future, Pandolfi outlined the new aspects of industrial research within the Industrial and Materials Technologies program of the Third Framework Programme (1990-1994).

On the technical side, two themes that will run through the whole program are the environmental aspect of products and processes and the working environment. In research on materials, we are emphasizing the whole life-cycle aspects from their production to design for manufacturing, use, and ultimately recycling.

When it comes down to how we implement the new program, there are several new things we have in mind. Namely, we now have a new legal instrument available to us--the European Economic Interest Grouping--which should facilitate putting together large projects. I am particularly keen to see projects based around a nucleus of large companies with what one could term a constellation of SMEs associated. In this way, I hope to see the particular capabilities of each type of company harnessed. The association of SMEs in projects of this kind will be one criteria our evaluators will look for in evaluating project proposals.

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for Industrial Assessment in Computer Science and Telecommunications.

Finally, Pandolfi concluded by locating European industrial research within the more general context a range of long-term developments as he said:

I will end by brieflv mentioning what I see as the most important challenges for the European Community (EC) as a whole in the coming years. The first issue of major importance is cooperation with third countries. There are several initiatives going on at the moment to which I attach great importance. For example, I have underway a number of specific cooperative activities with the U.S., and we have continuing discussions with European Free Trade Association countries as a group. Several are already involved in some of our research programs, and they make a financial contribution to those in which they are involved. These *ad hoc* cooperative agreements have grown in significance with the more recent moves toward creating the European Economic Space.

A much harder challenge for the EC is how to support the countries of Eastern and Central Europe in their path from centralized economies to market-driven economies. Science and technology (S&T) certainly have a large part to play here, but we also need to be very discriminating in the initiatives we put forward. There is a particular need for technology transfer to these countries; by technology, I mean carefully targeted technologies rather than advanced technologies. This will be essential to bring the industries of these countries up to minimum standards of efficiency, safety, and cleanliness.

Last, there are the more general challenges for the EC, all of which will have an impact on S&T to a greater or lesser extent. Simultaneously, we must achieve the completion of the Single Market, economic and monetary union, and political union, if the full benefits are to be felt by all of Europe's industry. Likewise, the revolutionary changes in Eastern and Central Europe mean that the EC cannot sit still. Alongside the reinforcement of the EC's role in foreign affairs and defense, must go a reform of its institutions and a reinforcement of their democratic basis. These challenges are all the more difficult for being simultaneous, but they are all the more important viewing the very rapid evolution of events in the world.

Mr. A. Hoffait, Central Research Director, Solvay Company, Brussels

In his remarks, Hoffait focused on the chemical industry in Europe. Of the world's 10 largest chemical companies, 8 are European and 2 are American; and of the world's 20 largest, 12 are European, 7 are American, and 1 is Japanese.

A major reason for Europe's predominance in this industry is that it started more than 125 years ago. In its early years, it dealt mainly in commodities. The American chemical industry started mainly after World War II.

At the end of the last century, Solvay had business, not only in Belgium, but also in the U.S. and the rest of Europe including the U.S.S.R. By then, it dealt in pharmaceuticals and chemicals.

Among Solvay's more recent and innovative developments has been germanium (Ge), silicon (Si), and gallium arsenide (GaAs) products. Although the development of a new drug is less spectacular than the launching of a new satellite, the chemical industry plays an important role in such industry actions as:

- Reduce industrial impact on the environment
- Create balanced portfolios between commodity production and research
- Compete effectively.

In Europe, the chemical industry has been faced with certain national barriers: multiple registration incurs multiple expense; market is less extensively homogeneous than in the U.S. and Japan.

The expectation now is for a better commercial environment because of:

- Integrated Europe
- Harmonized standards throughout the EC
- Harmonized manufacturing practices
- Acknowledged research from other countries
- Regulated community wide.

As a result of harmonized regulations, the risks should be much the same for all participants in the industry. However, it is hoped that restrictive regulations may be avoided. Such regulations could put Europe at a disadvantage. Regulations should be implemented in an encouraging manner to entrepreneurs. Europe spends 2.1 percent of its gross domestic product on research, whereas in the U.S. the figure is 2.8 percent and in Japan it is 2.6 percent.

The Europeans have reacted very positively to the programs of European Strategic Programme for Research and Development in Information Technologies (ESPRIT), Research and Development in Advanced Communications Technologies in Europe (RACE), and BRITE/EURAM. There has evolved a new spirit of cooperation among the countries in the EC. The working partnerships are similar to those in Japan. There is still a need for more vertical collaboration to include the scientist, the transformer, and the user. However, horizontal collaboration is also important.

The relation between universities and industry is vitally important:

- Avoid losing leadership in a technology
- Foster a high quality educational network
- Create a truly fruitful partnership between educational institutions and industry.

Europe needs to retain a strong technology base, and the EC should support the fundamental research as its first priority.

Mr. P. Richard, Scientific Director, the Bouygues Group, St. Quentin en Yvelines, France

The Bouygues Group (Group) is in the construction industry, mainly in France, involving housing, road building, and other building like operating facilities for oil and nuclear power. The Group also does independent integrated engineering, which varies somewhat from one country to another.

Much of the engineering work is based on mathematics; e.g., calculation of stresses from wind and waves. This industry, one of the oldest, is sometimes accused of showing little interest in research. Actually, the industry involves advanced technology. Obtaining a prototype may require new computer models and a study of new production materials.

The construction industry spends lots of money on research, has a good productivity level, and is competitive throughout the world. We are not necessarily able to work with universities, as we cannot always gain from basic research.

Construction needs are considerable in developing countries. European companies will participate only if the work is mutually beneficial. Engineers must increase research and development (R&D) to meet growing demands and to tackle world competition in, for example, synthetic materials and aviation industry needs. The future market will be characterized through such projects as underwater tunnels; e.g., the English Channel Tunnel and the Danish Link (between Denmark and Sweden).

Studies are needed to develop improved materials, including concrete compression stresses and all kinds of civil engineering materials for use in bridge building and wind tunnels.

A scientific approach to vibration calculation is needed, using the latest progress in mathematics. Research in construction engineering must attract young engineers. Such engineering will often combine old, new, basic, and advanced technology.

I strongly support the BRITE/EURAM program. Often a single company cannot find all of the required competence and resources to accomplish the work that needs to be done. Cooperation is useful with others not necessarily in the same country to:

- Understand European partners better
- Help to build European expertise
- Allow a European philosophy to develop.

Mr. Gordon Adam, Vice President, European Parliament for Science, Research, and Technology

European technology can best be illustrated through the manufacture of products. The traditional industries in Europe employ 40 million people. Our economic strength lies in the traditional industries. This is why BRITE/EURAM represents such a key focus for action. Our agreement on this point today is simply not conveniently tailored; it is a profound conviction. We need a systematic integration of technologies for the traditional industries.

Some aspects should be given priority in the European Parliament. The strategic character of the program should apply to all programs, avoid scattering of resources, and ensure that choices are made clear and alternatives are considered. The aeronautical sector is a big priority. Should other sectors like railways and maritime transportation have equal priority? Defining precompetitive research is not easy. Basic research is research that is furthest upstream. Clearly, this research must be continued and increased.

Another important consideration is the involvement of SMEs. The BRITE/EURAM program has the highest rate in this area, with 428 SME firms of a total of 1,123 firms. I look forward to an increase in SMEs.

Decentralizing EC programs is a real management problem. Some of the less-developed regions of the EC are failing to achieve. We find that the technical differences between them and the rest of the EC are greater than the economic differences. We need to give more attention to the scientific and development deficiency of the regions.

Ireland is a particular example where BRITE/EURAM can contribute. Attention must be given to national and regional measures to ensure greater SMEs involvement. The BRITE/EURAM program is a key EC program that can be a vehicle for this purpose.

There is also a need for lessening environmental pollution through clean technology and environmentally friendly manufacturing processes. There are serious environmental problems--in Poland there is an estimated 15 percent loss of production because of pollution.

We must also take measures to assist the countries of Eastern Europe. The needs there are enormous because manufacturing processes are obsolete. The BRITE/EURAM program is a good example of the sort of technology that is needed in Eastern Europe. However, we do not, at present, have the resources to extend to Eastern Europe.

Possibly, we can assemble teams of researchers to create the best possible conditions to assist eastern European countries. I hope to see sectoral teams going east. This can be a new and exciting challenge and may help the EC to realize its own objectives.

H. Tent, Deputy Director-General for Science, R&D, Commission of the EC

Cooperative R&D has taken over from in-house R&D in companies in the EC. This trend is not limited to large companies because smaller companies have become more aware of the importance of Sα ι. We only need to look at the number of joint ventures to realize how collaboration pays off. Sometimes an investment of £2,000 will give access to £4 million of research. Ninety-five percent of companies in manufacturing are SMEs, and although not all have an interest in research, the minority that has such an interest is important.

In collaborative efforts, it is important to foster openness and equal opportunity to all parties involved. Access to information should be easy and complexity of procedures should be lessened.

The EC needs to reach more people. This problem is similar to that of any large multi-national company. Among the problems we face are the preparation of proposals, delays in proposals, and the high rejection rate. Policy must constantly be improved and adapted to the circumstances. Small companies gain much, perhaps most, from collaboration. Collaboration should be motivated by factors other than just financial. There must be a commonality of interest and of competence. Motivation should be a mixture of business, finance, and knowledge.

When questioned about the intention of existing partners in projects to continue their cooperative relationships after the conclusion of the project, 68 percent said *yes*, 31 percent said *no*, and 1 percent said *don't know*. The collaborative programs have the greatest effect on high-technology companies and on companies with more than 5,000 employees. Ninety-four percent of those questioned said that they would continue to submit proposals.

New Materials

This session focused on new materials development.

Eudialyte - An Alternative Raw Material for Tetragonal Zirconia Polycrystal (TZP) Ceramics, J.S. Damtoft, Aalborg Portland, Aalborg, Denmark

The aim of this project is to investigate the possibilities for producing high-quality, low-cost zirconia ceramics by:

- Using mixed stabilizers, based on oxides of cerium and other inexpensive rare earth elements (REE)
- Preparing closely specified powders by simple processing of the mineral eudialyte.

Eudialyte is a silicate mineral, found in South Greenland, typically containing 13.4 percent (by weight) ZrO_2, 2.2 percent REE_2O_3, and 0.4 percent Y_2O_3.

Starting in 1988, the first phase of the project:

- Developed a method for extraction of Zr and REE from eudialyte
- Developed a procedure for powder preparation and studies of mixed REE-stabilized TZP, based on commercially available chemicals.

In the second phase of the project, the two lines were combined for the purpose of producing TZP test pieces from eudialyte feedstock. A eudialyte concentrate was derived from an ore sample by dry magnetic separation, using a superconducting magnet. Zirconium and REEs were brought into solution by boiling the eudialyte concentrate in 45 percent sulfuric acid using a 5 1 glass reactor. Separation of Zirconium and REEs from the sulphate solution was done by a two-step solvent extraction process. A method for powder preparation was developed using commercially available chemicals. A sulphate stock solution, similar to the feedstock obtained from eudialyte, was prepared by dissolving the chemicals in sulfuric acid. Mixed hydroxide was precipitated by addition of an ammonia solution while agitating using a high-speed turbine stirrer. The precipitate was washed in ethanol, dried at 50°C while ball milling at regular intervals, calcined at 1,000°C for 30 minutes, and finally wet-ball milled in ethanol.

Ceria-stabilized powders have been produced using zirconium from eudialyte. The powders were produced using the eudialyte derived feedstock by the method described above. The properties of the eudialyte-derived powders are similar to the powders prepared from commercial chemicals.

Research during the last part of the project will be concentrated on obtaining larger quantities of TZP powder, with better properties from the eudialyte feedstock, and on testing the effect of mixed REE as stabilizers on corrosion resistance and TZP mechanical properties.

Glass Fiber Reinforced Composite with Modified Cementitious Matrix, P. Soukatchoff, Centre de Recherches de Pont-a-Mousson, France

With age, glass fiber-reinforced cements currently available demonstrate a significant reduction in flexural strength and strain capacity. This greatly restricts potential practical applications. The performance of fiber reinforced composites could be improved if the matrix were modified by the addition of active mineral filters with or without polymers.

Different pozzolanas have been tested; e.g., pulverized fuel ashes, condensed silice fumes, and metakaolinites. Test results showed that metakaolinites have very promising strength retention. On samples of composites, one metakaolinite with special Portland cement and acrylic polymer additives can provide a long-term strain capacity after different accelerated aging tests, such as aging in hot water at 50°C, in wet/dry cycle test and freeze/thaw test.

The goal for this BRITE project will be:

- Determine the best polymer addition and the best amount
- Continue hydration kinetics studies and the different types of matrices in different curing conditions
- Observe the matrices, especially the interphases between glass fibers and the cement hydrates
- Reinforce with glass fibers mechanical properties of the best system cement metakaolinite-polymer.

Fiber-Reinforced Plastic Composite Engine, B. Cummings, Ford Motor Company, Dagenham, U.K.

This project's aim was to use a multidisciplinary team, drawn from different EC countries, to design and build a 4-cylinder, 4-stroke engine incorporating plastic composite materials into as much of the engine structure as feasible. Potential application to moving parts was not within the project's scope.

Earlier studies, between Ford Motor Company, Dagenham, U.K., and the National Engineering Laboratory (NEL), indicated that the most successful approach would be using a central core of conventional metallic materials and composite materials for the engine's outer walls. Consequently, this approach was adopted. To assist with part manufacture and as a first step into this type of engine design, it was decided to make the composite structure in three sections and to exclude any part of the engine cooling system from these parts.

After testing a variety of alternatives, Shell Epon 9400-9450, an epoxy resin was chosen for the crankcase and chaincase. The glass fiber used in the crank and chain cases, Vetrotex Unifilo U720-450, is a continuous fiber random mat (CRM). This glass fiber mat is made by swirling the fiber as it is deposited in a random manner in both directions of the mat's plane.

For the prototype, Vetrotex molded the crankcase panels and NEL molded the chain case. Galvanoform made the tools for the crank and chain cases by electrodeposition. Resin Transfer Molding made the composite parts. The cam cover and sump were introduced to support specific investigations. The cam cover was made by injection molding into a prototype tool by spraying zinc metal onto a model of the cover, then reinforcing it with a composite backing, and setting it into a steel frame. The composite oil pan was included to demonstrate how high load-carrying performance could be predicted. The oil pan was made using a resin tool, thus only a slow, room temperature could be used for the part itself.

The engine performance produced the same power and torque as an all-metal version. Testing indicated the potential for up to a 5 percent fuel saving with a composite engine because of the reduction in thermal inertia. The faster warmup resulted in a potential for a 20 percent reduction in engine-out hydrocarbon exhaust emissions. Also, the car's heating system will become effective sooner. The composite structure provided a 3.1 dBA reduction in average noise level. There is anticipation that a weight saving of 10 percent over a conventional aluminum block and 30 percent over a cast iron block can be achieved.

Manufacturing Techniques

In this session, three discussions focused on manufacturing technologies.

Surface Engineering of Titanium Components, T. Bell, University of Birmingham, Birmingham, U.K.

The program's objective is to enable engineers and manufacturers to design high-strength/weight ratio components in titanium alloys for operation where excessive wear currently makes titanium unacceptable. To enhance the tribological and load-bearing characteristics of titanium alloys, the modern surface engineering techniques of plasma thermochemical treatment and physical vapor deposition (PVD) coating, and electron beam and laser surface alloying are being studied and developed. The research is accomplished at the University of Birmingha.ı and the Technical University Clausthal.

Five tasks being executed are:

- Plasma thermochemical treatment and PVD coating
- Interstitial alloying by laser melting
- Substitutional alloying and compound formation by laser and electron beam
- Particle injection and combination treatments
- Quality assessment.

Development of a Reactive Ion-Plating Barrel System, D.G. Teer, D.G. Teer Coating Services Ltd., Hartleburg, U.K.

An established technique for the production of resistors now is the PVD of metal films in a barrel system where the samples are tumbled in a rotating barrel. A barrel ion-plating system, IVADISE, is also used to deposit all over coatings of aluminum on steel or titanium aircraft fasteners to provide corrosion resistance. However, the IVADISE coatings tend to have an open structure, requiring a post deposition glass bead shot-peening treatment to densify the coating. Recently, we have developed a magnetron sputter barrel ion-plating system that produces resistor coatings of higher quality, with improved uniformity and repeatability over previous systems. Also, it can be used to deposit dense aluminum and aluminum alloy coatings requiring no post deposition treatment.

In a parallel program, we have developed a system based on reactive magnetron sputter ion-plating that is giving excellent results in production coating of tools and other work pieces with hard, wear-resistant coatings such as TiN, TiAlN, and TiCN.

The aim of the present project is to combine these two techniques, and develop a reactive sputter, ion-plating barrel system in which many small objects could be coated all over with wear-resistant and/or decorative coatings of titanium nitride. Very good coatings have been reliably and reproducibly obtained in our existing equipment, and it is certain that significant improvements will be possible with further development.

Laser Sheet Metal Welding, M. Cantello, Istituto per Ricerche de Technologia Meccanica, Torino, Spain

Optimum processing parameters have been defined for coated and uncoated mild steel used in the automotive industry. The zinc, chromium, and aluminum coatings produce vapor ejections causing faults in welds by any process. To prevent this, the use of gaps between sheets was successful. For aluminum alloys, laser welding requires further research to eliminate porosity; the laser process yields a much smaller grain size in the bead compared with arc processes, and deformation on the pieces is much smaller.

During welding, the visible luminous emittance was correlated with the penetration depth of the laser beam in the metal, and a linear relation was found between luminous intensity and penetration up to 2 mm on steel and laser power up to 1 kW. A sensor has been designed that can detect the luminous intensity emitted to control keyhole striking. Further research will design the system for feeding back laser power to the level required for correct weld bead penetration. Table 1 provides some industrial applications for mild steel.

Table 1. Mild Steel Industrial Applications

- Rotating clamps numerically controlled and coordinated with movement of component to be welded
- Laser linear welds on coated and uncoated box structures for car applications - compared to spot weldings in fatigue tests
- The Aerospatial Airbus A320 Capot Echangeur component in stainless steel or titanium using two different welds
- Large diameter thin cylinders - typical of modules used in aeronautic and aerospatial applications; joining calendered titanium sheets by laser being developed with Aeritalia.

Application of Manufacturing Systems

Three presentations discussed several manufacturing systems applications.

New Methods for High Accuracy Measurement of Aspheric Surfaces, G. Harbers, Philips Research Laboratories, Eindhoven, the Netherlands

Under this project, high-precision test methods for aspheric (nonspherical) components and tools in optics are being developed. These aspheric components are now used in modern optoelectronic equipment, such as cassette disk players and projection television systems. Using aspheric optical elements, these systems can be much smaller and cheaper. With demands for decreased dimensions, the required accuracy of the components in new generations of optical recorders increases. The production of the required aspheric surfaces is not easy, and is strongly dependent upon the available measuring techniques.

In the original work plan, the study of several measurement techniques was required:

- Conventional Twyman-Green interferometer using computer-generated holograms
- Radial shear interferometer
- Knife-edge and wire-test techniques
- Two-wavelength interferometer.

None of the above techniques was suitable because all required the use of collimator lenses, which are large and have many optical elements that introduce significant errors. New methods were developed where a collimator lens was unnecessary. These new methods are the parabolic Fizeau interferometer and the meniscus lens interferometer.

In the parabolic Fizeau interferometer, the aspheres are no longer measured with reference to a sphere, but with a parabola as reference. A parabola focuses a parallel beam into a point. In the Fizeau interferometer, a partially transmitting mirror is placed at the focus, and the reflected light will emerge as a parallel beam for the interferometric measurement. No collimator lens is needed. Thus, the associated errors are no longer present. Also, the interferometer is very compact, stable, and suited for use in a production environment. Aspheres can also be considered as parabolas with deviations, and as long as the fringe densities introduced by these deviations can be resolved by electronic cameras, accurate measurements will still be possible.

Hybrid Optical/Electronic Industrial Vision System, HII, N.B. Aldridge, British Aerospace, Bristol, U.K.

The main elements of the HII system will be a data acquisition system, including a camera mounted on a robot arm, a multichannel optical preprocessor, an updatable optical correlation channel, a knowledge-based system (KBS), and a computer-aided design (CAD) database.

The project is exploiting the parallelism and speed of optical processing techniques by performing the bulk of the computationally intensive image processing in this domain. The KBS will formulate inspection strategies based on CAD, and ideal object models. Also, it will monitor, control, and reconfigure the optical processors and input sensors according to the inspection strategy. Central to the HII system, is a dynamic frequency plane optical correlator. Models generated by the KBS are written as holographic-matched spatial filters in a crystal of photorefractive bismuth silicon oxide, and correlated against the real-world image. The spatial frequency correlator response, and hence its discriminating ability, can also be controlled by adjusting the relative strengths of the writing beams using a liquid crystal attenuator device.

The interfaces from the real world and the KBS to the optical processing channels will be via frame store to miniature cathode ray tube (CRT)--a spatial light modulator, CRT/SLM, combination. The SLMs will be optically addressed GaAs/liquid crystal devices fabricated as part of the project.

The Conoscopic Camera: a Three-Dimensional (3-D) Vision System, D. Charlot, Le Conoscope S.A., Montigny le Brettoneux, France

The first system developed by Le Conoscope S.A. is a range finder. The system is similar externally to a television camera, and is built from a charge-coupled device camera, the conoscope--which looks like an optical pre-objective inserted between the camera and the lens, and an illumination module based on a diode laser. No complex calibration procedures are needed, and the system is almost insensitive to noise and vibrations. The first range finder, at a data rate of 1,000 points/sec, will be available in 1991.

By adding a scanner to the range finder, an accurate, versatile system can be built. Computer controlled, it will make possible automatic measurement of the position of chosen points on an object or a surface, and will have application in meteorology.

The profilometer makes possible the recording of a complete line of an object. Externally, the profilometer sensor will not differ from the range finder, and the software/hardware package will be similar to that of the range finder. The applications of the profilometer are mainly in quality control where its line geometry is well adapted to conveyor belt geometry.

The grid-points camera makes possible the recording of a complete dense grid of points on an object with high accuracy. The range-finder hardware can be modified to obtain the information of the grid and the software/hardware package has been developed for reconstruction of the object form based on this information. The applications are in metrology.

Manufacturing Techniques

Three presentations discussed different manufacturing techniques.

A New Low-Cost Replication Technique for Making Tool Steel Dies, A.R.E. Singer, Sprayforming Developments Ltd., Swansea, U.K.

Although die replication by spray deposition has been used for certain low-temperature metals, it has never been possible to extend it to tool steels. This is because of major distortion that occurs as a result of the buildup of internal stress during the deposition process.

The new process of simultaneous spray peening (SSP) pioneered and developed by Sprayforming Developments Ltd., enables a spray deposit to be developed in which the internal stress can be controlled at any required level. The SSP process comprises the gas atomizing of molten metal to form a spray that is directed onto a cool substrate. The molten metal droplets splat and solidify when they impact the substrate, building up rapidly to form a spray deposit. Simultaneously with the deposition process, the deposit is peened with steel shot or steel balls. This has the triple benefit of densifying the deposit, hot-working it, and reducing the internal stress in a controlled manner.

The control of internal stress is possible because spray deposition leads to high internal tensile stresses, whereas peening leads to high internal compressive stresses. By regulating the speed of peening, the compressive and tensile stresses can be arranged to cancel one another or to be controlled at whatever level is required. This ability to control internal stress, and at the same time replicate detail accurately, is the center of the feasibility study.

Making dies by replication on a defaced coin was chosen as a good test method because it would show whether fine detail could be replicated, and the dies were small enough to be manufactured within the small funding limits of a feasibility study. Also, it would show any distortion of the dies that might occur during manufacture.

Replicated dies were made in 13 percent chrome hot die steel using an arc spray gun with simultaneous spray peening. The experimental procedure was to spray deposit for a few seconds without peening to enable a 0.5-mm layer to build up. Peening then commenced and continued simultaneously with deposition until a sufficient thickness had been built up to enable a tool or die to be made. The dies were measured accurately to determine any distortion and detail loss during replication. Some were then mounted onto a die holder and used to press coins that were similarly examined.

The results were promising and replication was good. The next step is to select a suitably small set of dies of that interest industry for replication using a master made from a suitable material. Subsequently, the tools and dies must be heat treated and tested in a simulated industrial cycle before being used for the pressing or stamping of components.

Flexible Unit for Removing Textile Work Pieces from a Pile and Overlaying Them, P. Esquirol, Armines, École des Mines d'Ales, France

The main objective of this program is developing workstations that will be able to grip and separate a single ply of fabric, from multiple precut stacks, making a new multi-ply stack. New research has started to define handling techniques useful for local gripping, local separating, total gripping and separating, and also vision techniques for supervising and checking the operations.

The main process is based on the accurate decomposition of successive operations to be accomplished in order to destack and superimpose textile piles: arranging, recognizing, separating, local or complete gripping, turning, moving, and placing. Five main tasks are scheduled: (1) characterizing the material being gripped, (2) studying reliable material adhesion principles, (3) studying piece localization by vision systems, (4) studying several destacking devices, (5) and testing operations in garment workshops. The principal tools necessary to the program are now in place. The results obtained at the end of the program will be directly applicable in an industrial environment.

Numerical Simulation of Injection Molding and Prediction of the Shrinkage Towards Computer-Aided Design and Optimization of Industrial Automation Components, F. Dupret, Universite Catholique de Louvain, Belgium

The aim of the project is producing software that models the flow of polymers during the forming of industrial electromechanical parts. Each cycle in injection molding consists of: preplasticizing the polymer, filling the cavity, packing the material within the mold, cooling the injected polymer, and ejecting the solidified part.

We have developed a numerical method for simulating the molding of thin parts, assuming that injected thermoplastics behave as generalized Newtonian fluids, with viscosity dependence upon shear rate and temperature. We also assume that molded parts are characterized by a multifaceted midsurface of varying thickness.

A specific goal was exploiting the flexibility and accuracy of the finite-element method. Approximate temperature and pressure fields are calculated during filling, using successive finite element meshes. The method consists of selecting, at the outset, a well-behaved mesh covering the whole midsurface. During filling, the front moves through this mesh, while the program generates successive temporary meshes recovering as many elements as possible from the original one.

Accurately calculating the thermal evolution during the filling and packing stages is essential. During the filling, the energy equation is a balance among heat diffusion in the gap direction, heat advection in the midsurface direction, and viscous heating within the polymer. This equation is solved using the 3-D method developed by Vanderschuren and Dupret (Vanderschuren et al., 1986), and Dupret and Vanderschuren (Dupret et al., 1988), together with the specific handling of the fountain flow effect. Care is required in the extrapolation procedure between successive meshes.

Packing stage calculations are performed on the fixed mesh. Compressibility effects are considered. A 3-D technique is used for simulating the cooling phase, during which deformations are assumed to be small applying linear thermoviscoelasticity and obtaining the shape of the molded part.

Closing Plenary Session

In the closing plenary session, there were two speakers from industry, one from a university, and one from the EC.

L. Beckmann, Deputy Director, R&D, Oldelft-Twent University, the Netherlands

Beckmann spoke almost entirely about preparing and presenting proposals for BRITE/EURAM projects; i.e., how to present it, what to emphasize, and what to avoid.

The rules must be adhered to strictly, and for this purpose the guidelines are useful. Proposals will compete with each other based on novelty, creativity, technical appeal, capability, realistic planning, and pleasing presentation.

The proposal should make a clear statement of the problem to be solved. Also, it should be completely reliable and honest with no complicated language, no ambiguous terminology, no reference to literature, no wishful thinking, and no jargon. The proposed solution should be presented understandably, with appeal to an educated technologist. The proposal should be accompanied by a realistic and convincing budget and time schedule, which will give some evidence of management capability. Also, it should include a local project structure, a statement of what is being delivered at the project's end, and a risk assessment.

Briefly, the ideal BRITE/EURAM project solves a strongly perceived problem and advances the state of the art by healthy confirmation through good ideas and work. The project also creates, intensifies, or advances transnational cooperation of qualified partners. In addition, it strengthens all participants, yet preserves their identity. Finally, it provides long-term benefits for all concerned.

A. De Bonis Canada, Director, Diseno y Metodologia (DYM), Madrid

De Bonis Canada talked about the role of a small company leading a large project. His company has 25 employees and is primarily concerned with developing software for the manufacturing industry. The company is experienced in European collaboration through participation in projects as a partner or subcontractor. The DYM company is collaborating with several other companies in a project involving the development of software, using expert systems for application in the manufacturing industry. His advice was:

1. Describe the project accurately
2. Choose appropriate partners
3. Define your solution.

Regarding EC as a partner in the enterprise is important because EC suggestions are made in good faith. Advantages to joint participation are: more opportunity for success, and each partner benefits from teamwork.

J.P. Rique, Director, Industrial Division, International Celomer, Le Havre, France

Celomer produces industrial paints and has 260 employees. The annual turnover is 40 million European Currency Units. Celomer is a leading paint supplier in France and exports 15 percent of production to the FRG, Italy, and Spain. The company would like to increase its exports and be a leader in its field.

Our interest in BRITE/EURAM collaboration is based on:

- Paints are becoming increasing performant and chemically resistant
- Aircraft finishes are stripped every 5 years and the aircraft repainted
- Paint strippers are becoming less efficient
- European legislation on environmental protection is causing reduced efficiency.

Celomer's strengths as an industrial partner in a BRITE/EURAM project include: in-depth knowledge of the aeronautics industry, its relationship with Aerospatial and with Air France, and the image it enjoys as a company with technical experience. Celomer now has 14 joint contracts including 5 universities, 2 research laboratories, and 6 industrial companies. However, its weakness includes lack of experience in microencapsulation, which is to be tried out in the paint industry. Celomer also lacks R&D money. The solution may be combining strengths with other companies and seeking financial assistance through the EC.

The partners in the project on microencapsulation in the paint industry are International Celomer, Aerospatial, the University of Athens, Central Organization for Applied Scientific Research (TNO) (a company with experience in microencapsulation), and Institut de Recherche d'Automatique (IRA) (a French research laboratory with experience in microencapsulation of liquids).

Some difficulties encountered in a joint project are: finding suitable partners, motivating for cooperation, creating a financial base, establishing the research program, and working together on an agreed plan. Feedback is necessary on such matters as: anticipating requirements, internal synergy, approach to the problem, innovation level, and external synergy.

A. Garcia Arroyo, Director, Technological Research, Commission of the EC

The two productive days of this conference has provided an opportunity for participants to meet and discuss their work with their counterparts and friends. Yesterday Messrs. Pandolfi, Tent, and Adams spoke about the future. I now want to take a few moments to reinforce some of the concepts of the actual BRITE/EURAM program.

During the 2 days, I walked around and chatted with some of the participants and have had very positive opinions concerning the program. Some facts about the program useful to understand are:

- Program is multisectoral and has application to specific problems
- Preference should go to the problems whose solution has widest application
- Purpose is to enhance and develop technology at its limits and find its applications
- Program is using technology to solve real manufacturing problems
- Program is fostering work with industries and other institutions with a systematic approach to solving practical problems.
- Through work with SMEs, program takes advantage of what is going on; thus, is helping 90 percent of European industrial companies.

On average, 6 months is enough to allow preparation of a good proposal. Table 2 provides some useful information from questionnaires.

Table 2. Questionnaire Responses

1. Participation has enabled respondents to work with a new partner - 80%
2. Participation has enabled respondents to do more than they otherwise possible - 80%
3. Participation has enabled respondents to engage a new field of work - 47%
4. Participation lead to creating a new research team - 31%
5. Work would have been done without the EC - 55% No, 45% Yes
6. How long would it take to reap benefits from the program - 94% (within 5 years)
7. Will continue the relationship with their partners in the BRITE/EURAM - 31% undecided
8. Continue to apply for BRITE/EURAM projects - 94%

References

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